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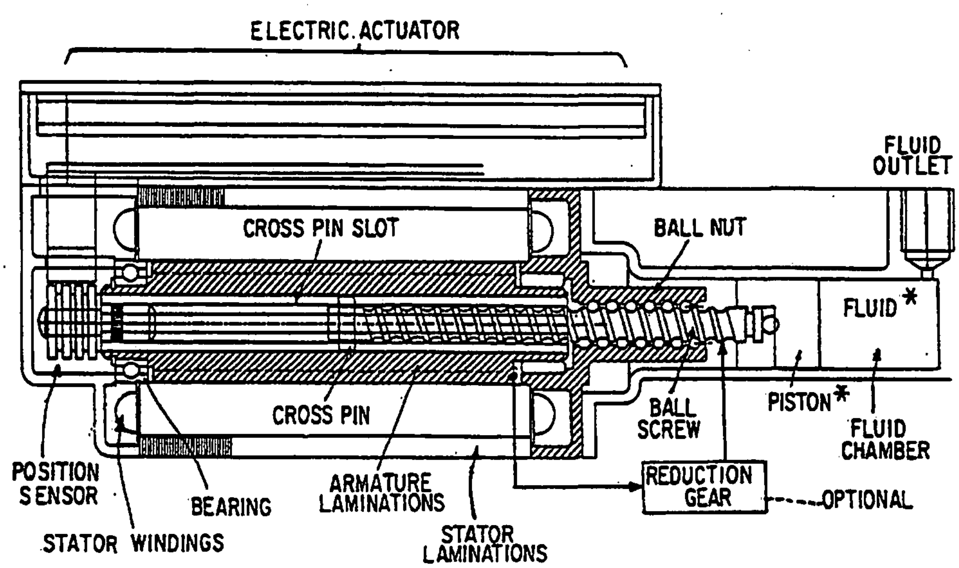

(57) Abstract

The invention concerns braking systems for vehicles. The invention provides one, or more, electrically actuated pressure generators, which provide hydraulic pressure for actuating hydraulic brakes. Electric actuation allows control by electronic signals, which are generated by a microprocessor-based controller. The pressure generators can be retro-fitted to existing hydraulic brake cylinders. The controller may be incorporated into, or operate in conjunction with, the on-board engine computer.

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VEHICLE BRAKE

The invention concerns brakes for vehicles. In particular, the invention concerns electrically actuated brakes, which pressurize a hydraulic fluid, using electrical energy. Electric actuation provides direct compatibility with electronic control systems, and allows retro-fitting to existing hydraulic brake systems.

BACKGROUND OF THE INVENTION

For present purposes, a braking system in a vehicle can, conceptually, be reduced to the following components:

-- A brake pad (or shoe) which engages, and applies drag to, a brake rotor (or drum).

-- An actuator (such as the brake cylinder/piston located at each wheel) for the brake pad (or shoe).

-- A control system which triggers the actuator.

Commonly, the control system responds to a foot pedal which is depressed by the driver, and causes pressurized hydraulic fluid to be delivered to the actuator. (A vacuum-assisted booster commonly amplifies the pressure generated by the driver.) In a simplified sense, the braking system can be viewed as a amplification-and-delivery system for hydraulic signals.

It is possible to use other types of signals, such as electrical signals, to control the actuators. One advantage of electrical signals is that the modern microprocessor provides enormous computing power for processing, and delivering, electrical signals. Inexpensive microprocessors available in the early 1990's can process individual program instructions at the rate of a few microseconds per instruction. (One microsecond equals one millionth of a second.) These processors can easily run at clock rates of 5 MegaHertz, thereby providing an overall computation rate in the range of millions of instructions per second.

The invention concerns the application of electronic control techniques to vehicle braking systems.

OBJECTS OF THE INVENTION

An object of the invention is to provide an improved vehicle braking system.

A further object of the invention is to provide a vehicle braking system which can be controlled electronically.

A further object of the invention is to provide a vehicle braking system which can be coordinated with the on-board ignition computer of a vehicle.

A further object of the invention is to provide improved traction control in a vehicle braking system.

A further object of the invention is to provide an improved anti-lock braking system.

A further object of the invention is to provide a braking system which influences attitude control of a vehicle.

SUMMARY OF THE INVENTION

In one form of the invention, an electrically powered actuator generates pressure which is applied to brake cylinders. The actuator is controlled by an electronic control system. The control system can apply different, programmed, braking pressure to individual wheels.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is one view of the invention.

Figure 2 is a detailed view of form of the invention, showing a device which provides a pump function.

Figures 3 - 5 illustrate, in schematic form, operation of the apparatus of Figure 2.

Figure 6 - 8 are overhead views of four tires of a vehicle, and illustrate different embodiments of the invention.

Figure 9 illustrates how the invention can be spliced into a hydraulic brake system.

Figure 10 illustrates a control system for reducing brake pressure during stops.

Figure 11 illustrates another form of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Actuator

Figure 1 is a schematic of one form of the invention. A CONTROL SYSTEM delivers a signal to an ELECTRICAL ACTUATOR, which drives a PISTON, which pressurizes a FLUID, which leads to a BRAKE, as indicated. The CONTROL SYSTEM receives various signals which it uses in its processing, as indicated.

Figure 2 illustrates one particular embodiment of the actuation system. Three components, labeled with asterisks (*), correspond to similar components in Figure 1. These are: ELECTRIC ACTUATOR, PISTON, and FLUID.

Figures 3, 4, and 5 are highly simplified schematics which illustrate some of the principles of operation of the device of Figure 2.

Figure 3 is an exploded, schematic view of selected parts of Figure 2. Of these, the BALL NUT is restrained against both rotation and lateral motion, as indicated by the ground symbol.

Figure 4 illustrates these parts when assembled. The CROSS PIN carried by the BALL SCREW engages the CROSS PIN SLOT, which is broached into the ARMATURE. This engagement forces the BALL SCREW to rotate synchronously with the ARMATURE.

As shown in Figure 5, when the ARMATURE is rotated, as indicated by arrow 18, the BALL SCREW advances in the direction of arrow 21, because it threads through the stationary BALL NUT. A PISTON, also shown in Figure 2, which is linked to the end 25 of the BALL SCREW, compresses fluid (not shown in Figure 5). The fluid actuates a brake, as in Figure 1.

Applications of Actuator

<u>One Application</u>

The ACTUATOR shown in Figure 2 can be used to generate pressure which is applied to brake shoes or pads. In Figure 6, the ACTUATOR delivers pressurized hydraulic fluid to the brakes B through brake lines 30. This actuation is induced by motion of a brake PEDAL, which generates pressure in a master cylinder, known in the art. The master cylinder is instrumented to detect the pressure. A CONTROL SYSTEM uses this pressure to infer the amount of braking force requested by the driver, and causes the ACTUATOR to apply appropriate pressure to lines 30. In the event of system malfunction, the brakes revert to obtaining actuation pressure from the master cylinder.

Variations in pressure generated by the ACTUATOR may be desired. How to cause variation is discussed later in this Specification.

<u>Second Application</u>

Another application is shown in Figure 7. Individual actuators A, each of the type shown in Figure

2, deliver fluid to their own respective brakes B. Each actuator A is controlled individually by a CONTROL, through electrical signal lines 33. In this embodiment, each brake B can be controlled individually. This individual control can be useful if the vehicle is equipped with an anti-lock braking system (ABS). The actuators described herein can be used to provide the ABS function.

In an anti-lock braking system, wheel speed is sensed, and braking pressure is adjusted, in order to prevent wheel speed from dropping to zero. When wheel speed is sensed to approach zero, some anti-lock braking systems initiate a response by overpowering the brakes applied by the driver, and forcing brake pressure to subside. That is, a second hydraulic system, in addition to the normal brake hydraulic system, overrides the normal braking action.

The embodiment of Figure 7 allows each brake to be individually relaxed, when the ABS detects that a wheel is about to lock. A hydraulic system which overrides the normal braking system is not required. (Neither an ABS, nor connection between an ABS and the CONTROL, is shown.) This ABS emulation is explained in connection with Figure 8.

In Figure 8, a speed sensor S detects speed of each TIRE. The sensors S deliver the speeds to a CONTROL along lines 38. When a given speed is detected as approaching zero, the CONTROL performs an anti-locking function, by relaxing the braking pressure applied to that wheel, thereby de-actuating (or reducing pressure applied by) the proper actuator A.

Use as Parking Brake

The actuator of Figure 2 can be used as an electrically energized parking brake. One approach is shown in Figure 9. The ACTUATOR is spliced into a brake line, as indicated by the dashed circle C. The ACTUATOR applies pressure to the brake line, thereby braking the wheels while the vehicle is parked, and unattended.

In order to eliminate the requirement that electrical current be continually applied to the ACTUATOR, a mechanical detent can be installed for locking the PISTON, as known in the art.

Alternate Embodiment

Figure 11 illustrates another embodiment of the invention. Several features of Figure 11 are the following.

A ball nut 51 is fixed to a housing 55, and does not rotate with respect to the housing 55. A ball nut bushing, or ball nut hybrid, 52 is affixed to the motor casing 54, to facilitate helical motion.

An armature shaft 53 comprises (a) a section 53A which carries a lamination stack 58, (b) a ball screw section 53B, and (c) a section 53C for connecting to a piston 56.

A stator unit 57 comprises windings of an S-R, or brushless PM motor. A lamination stack 58 is used for an S-R motor, or magnets for brushless PM motor.

An important distinction between the actuator of Figure 11 and that of Figure 2 is that, in Figure 11, the lamination stack 58 which forms the armature translates left- and rightward, as the shaft 53 rotates. That is, the lamination stack 58 shuttles left and right between points 60 and 61.

In contrast, in Figure 2, the ARMATURE LAMINATION/BALL NUT assembly does not translate. The BALL SCREW performs the translation, and shuttles left and right through the ARMATURE LAMINATIONS, which are stationary (but rotating).

Additional Considerations

1. The motor shown in Figure 2 can take the form of an alternating current (AC) motor. AC current can be derived from the battery of the vehicle (which produces DC current) by an invertor, or equivalent device. AC power has the advantage of allowing simple speed control, by pulse-width modulation (PWM).

However, AC motors are not required, and DC motors can be used. The particular type of motor is not necessarily significant, but several characteristics are desirable. One is that a high free speed is necessary, in order to provide good response. A second is a suitably high ratio of stall torque/armature inertia.

Additionally, a low-inertia armature is preferred, for short response time. A laminated armature stack (as opposed to a copper-wire-wound armature) provides low inertia.

Further, if a high-speed, low torque motor is used, then a reduction gear, indicated as optional in Figure 2, can be interposed in the drive train between the ARMATURE and the BALL SCREW.

2. A POSITION SENSOR in Figure 2 detects the position of the PISTON. The POSITION SENSOR produces an electrical signal which is usable by the CONTROL shown in Figure 7. Position detection can be necessary to limit the travel of the PISTON. For example, when the PISTON in Figure 1 is being driven rightward, the POSITION SENSOR (not shown in Figure 1) continually detects the position.

3. The torque produced by electric motors, in general, depends on the current drawn. In some types of motor, the rotor current is especially sensitive to motor torque. Therefore, motor current both indicates and determines motor torque, which indicates pressure of the FLUID in Figure 2. This fact can be utilized as follows.

Many vehicles employ a combination of disc- and drum-type brakes. Commonly, disc-type brakes are used on the forward wheels, while drum-type brakes are used on the rear wheels. One reason is that the forward brakes absorb most of the braking force during a stop, and thus must dissipate larger amounts of energy than the rear brakes. Disc-type brakes are suited to large energy absorption, because of their higher ability to dissipate heat, as compared with drum-type brakes.

However, for a given brake pad pressure, drum brakes provide greater braking force than disc brakes, partly because drum brakes are self-energizing. (The brake pad rotates into contact with the drum. When contact is made, friction drags the pad into slightly greater rotation, which applies greater pressure to the drum, thereby increasing braking drag.)

Therefore, because of the different braking forces obtained from disc and drum brakes, it is common to provide a pressure proportioning valve for allocating different pressures to each. During a stop, greater fluid pressure is directed to the forward disc brakes than to the rear drum brakes.

However, the proportioning valve does not provide optimum pressure allocation under all braking conditions. For example, during a light stop, the proportioning valve may provide proper allocation of pressure. But during a heavy stop, the pressure applied to the rear brakes may cause the rear wheels to lock.

The invention, as shown in Figures 7 and 8, allows pressure proportioning which can be controlled by an algorithm, which runs within the CONTROL. A very simple algorithm is the following.

During light braking (indicated by light pressure produced by the PRESSURE TRANSDUCER in Figure

6), one pressure is applied to the forward brakes, and a different pressure is applied to the rear brakes.

The different pressures are obtained by applying different currents to the forward actuators A, as compared with the rear actuators A.

In contrast, during heavy braking, greater pressure is applied to both the forward brakes and to the rear brakes than applied previously. However, the ratio of (forward pressure)/(rear pressure) during heavy braking is, in general, different than the same ratio during light braking. (This ratio refers to the pressures developed within the FLUIDs of the respective actuators. It can be related to the pressures applied by the brake pads to their respective discs or drums.)

In practice, a more complex algorithm will certainly be used, but will embody this basic principle.

4. During braking, many drivers ease up on pedal pressure as the vehicle approaches zero speed, in order to achieve a smooth, gentle stop, wherein the nose of the vehicle does not dip and then jump upward. The invention can automate this function.

For example, in many vehicles, as shown in Figure 10, a signal indicative of vehicle speed is fed to the on-board IGNITION COMPUTER. A CONTROL 40 taps this signal. During braking, when vehicle speed drops to a predetermined value, such as 4 miles per hour, the control 40 intervenes, and diminishes fluid pressure fed to the brakes, as by ramping the pressure down, as indicated generally by plot 45. This reduction in pressure can be obtained by reducing motor current, as discussed above.

Thus, a gradually lessening brake force is applied to the brakes during stops, without driver involvement.

5. The invention is not limited to use in self-powered vehicles. It can be used in trailers.

6. Pressure of the FLUID shown in Figures 1 and 2 need not be inferred from the current drawn by the motor. Other parameters can be used to infer pressure. It can be inferred from piston position. It can be measured directly, as by using a transducer in communication with the FLUID.

7. One feature of the invention is that it measures pressure in the vehicle's master cylinder and, based on the measured pressure, modulates pressure generated by an electrically-energized actuator (such as that shown in Figure 2), and applies the latter pressure to the vehicle brakes.

Numerous modifications and substitutions can be undertaken without departing from the true spirit and scope of the invention. What is desired to be secured by Letters Patent is the invention as defined in the following claims.

1. In a braking system for a vehicle, the improvement comprising:

a) an electrically actuated pressure generator, which delivers pressure to brake pistons located at vehicle wheels.

2. A braking system for a vehicle, comprising:

a) hydraulically actuated brakes located at wheels; and

b) for each hydraulically actuated brake, a hydraulic pump which is electrically actuated.

3. A braking system according to claim 1, in which the electrically actuated pressure generator produces pressure in response to pressure generated in a master brake cylinder.

4. A system according to claim 2, and further comprising:

c) a control for actuating each hydraulic pump.

5. A system according to claim 4, in which each hydraulic pump can be actuated independently of the others.

6. A system for providing a parking brake function for a vehicle, comprising:

a) an electrically actuated hydraulic pump; and

b) means for delivering hydraulic pressure generated by the pump to a hydraulic brake on the vehicle.

7. In a brake for a vehicle, in which hydraulic pressure is applied to a brake pad, the improvement comprising:

a) an electric motor;
b) a ballscrew driven by the motor;
c) a ballscrew nut, which
  i) is fixed in position,
  ii) engages the ballscrew, and
  iii) causes the ballscrew to advance laterally when the ballscrew rotates; and
d) a piston, contained within a cylinder which also contains hydraulic fluid, which
  i) is driven by the ballscrew, and
  ii) causes the hydraulic fluid to become pressurized when the ballscrew advances.

8. Apparatus according to claim 7, and further comprising:

e) a position sensor for detecting position of the ballscrew.

9. Apparatus according to claim 8, and further comprising:

e) a reduction gear interconnected between the motor and the ballscrew, for increasing motor torque applied to the ballscrew.

10. In a braking system for a vehicle, the improvement comprising:

a) means for detecting vehicle speed; and

b) means for relaxing brake pressure, when vehicle speed falls below a predetermined value.

11. In a braking system for a vehicle, which contains disc brakes and drum brakes, the improvement comprising:

a) means for sensing pressure applied to a brake pedal; and

b) means for applying different fluid pressures to the disc brakes, as compared with the drum brakes.

12. Apparatus according to claim 11, and further comprising:

c) means for changing pressures applied to both the disc brakes and the drum brakes, based on sensed pedal pressure.

13. Apparatus according to claim 13, wherein ratio of (pressure applied to disc brakes) to (pressure applied to drum brakes) changes as sensed pedal pressure changes.

14. A method of operating brakes in a vehicle, comprising the following steps:

a) allowing a driver to generate pressure in a master brake cylinder;

b) deriving a signal which indicates said pressure; and

c) using said signal to control one or more electrically powered actuators, which apply hydraulic fluid to the brakes.

15. The method according to claim 14, in which the electrically powered actuators modulate pressure applied to the hydraulic fluid, in response to changes in the signal.

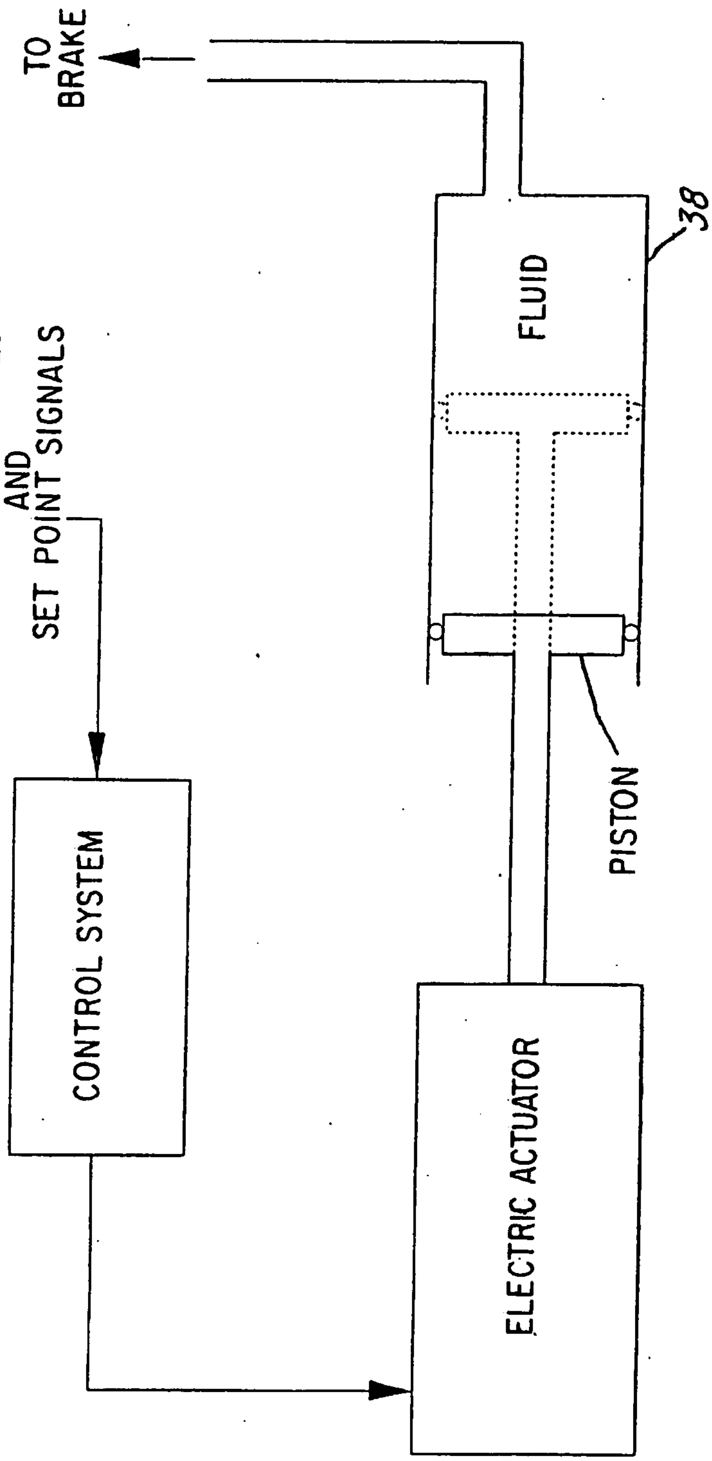

TO BRAKE
38
FLUID
FEEDBACK SIGNALS AND SET POINT SIGNALS
PISTON
CONTROL SYSTEM
ELECTRIC ACTUATOR

FIG-1

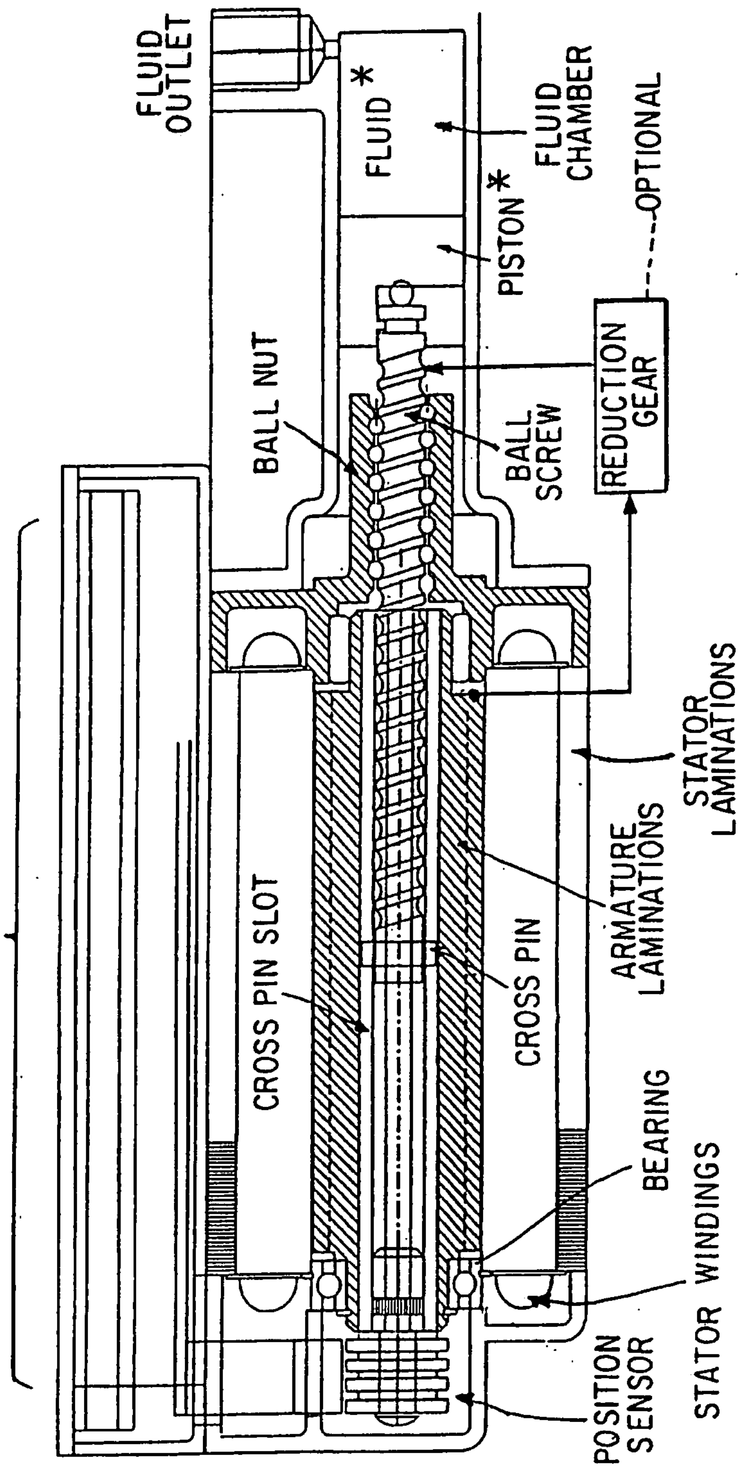

FLUID OUTLET
FLUID *
FLUID CHAMBER
PISTON *
OPTIONAL
REDUCTION GEAR
BALL NUT
BALL SCREW
ELECTRIC ACTUATOR
CROSS PIN SLOT
CROSS PIN
ARMATURE LAMINATIONS
STATOR LAMINATIONS
BEARING
STATOR WINDINGS
POSITION SENSOR

FIG-2

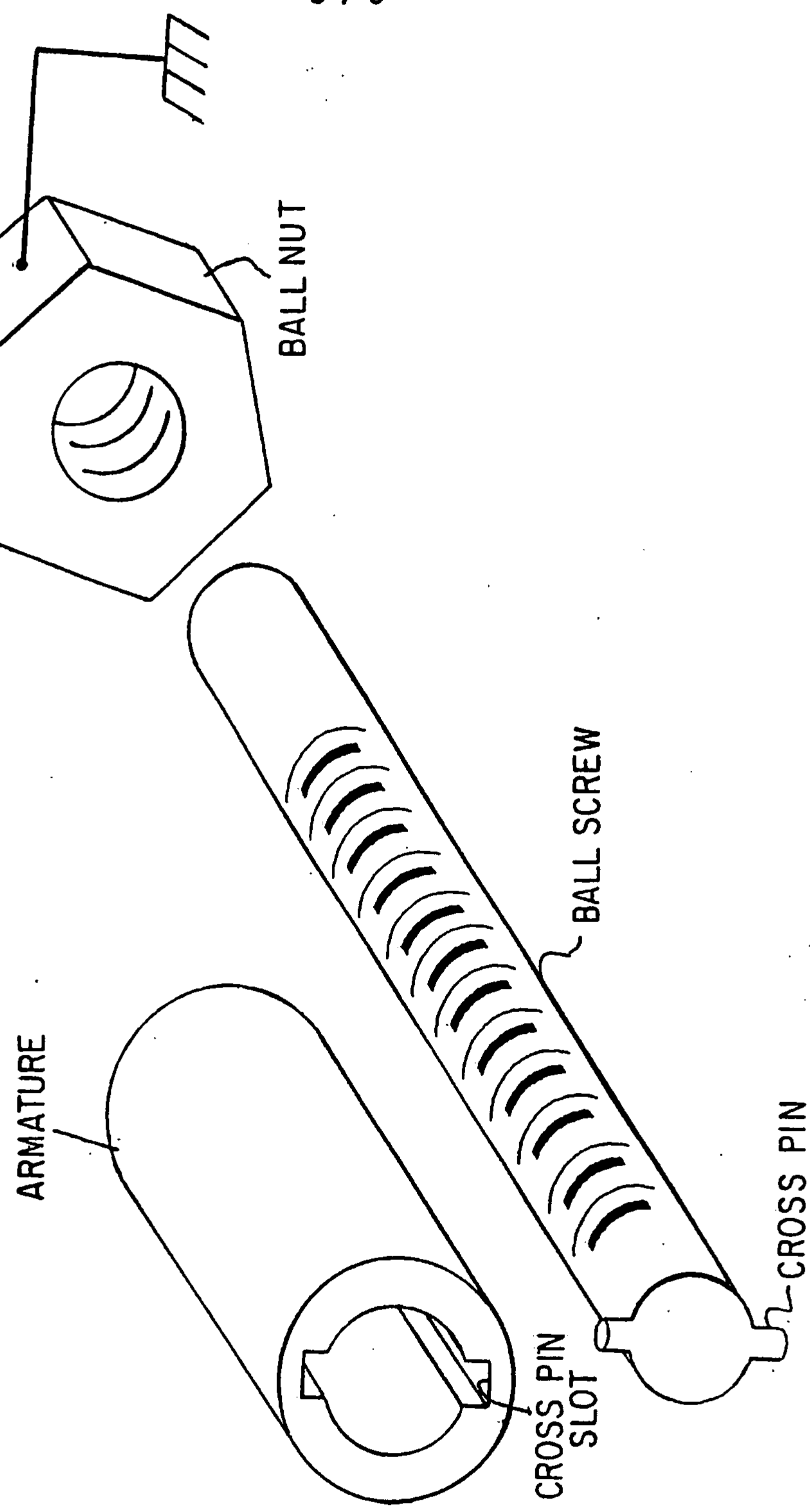


FIG-3

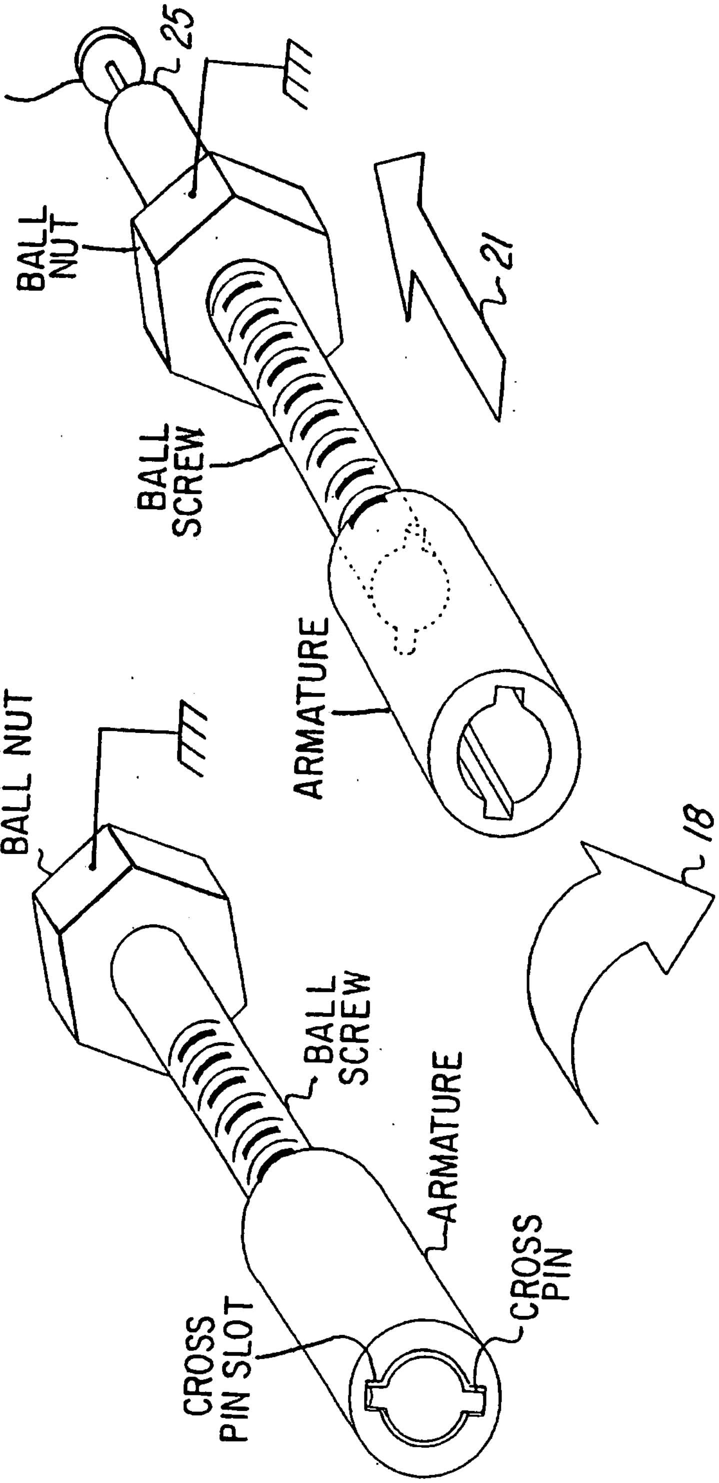

PISTON
25
BALL NUT
21
BALL SCREW
ARMATURE
BALL NUT
18
BALL SCREW
ARMATURE
CROSS PIN
CROSS PIN SLOT

FIG-5

FIG-4

FIG-7

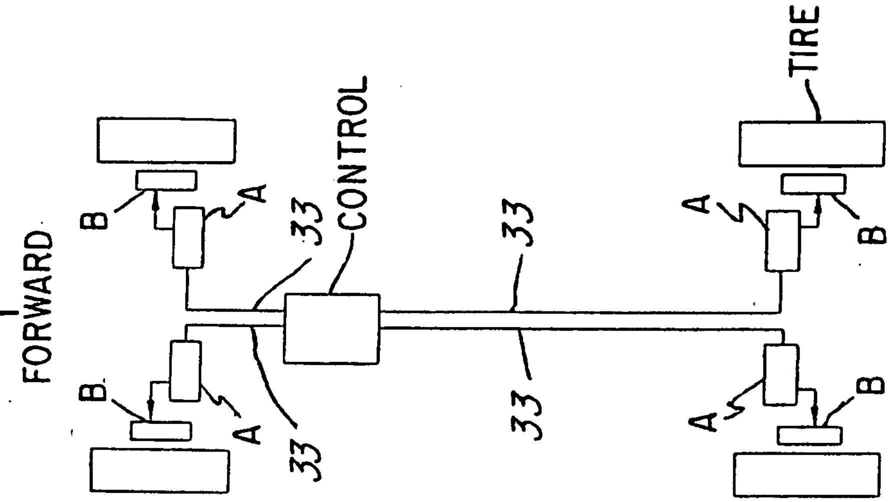

FORWARD
B
A
33
CONTROL
33
B
A
33
33
TIRE
A
B
A
B

FIG-6

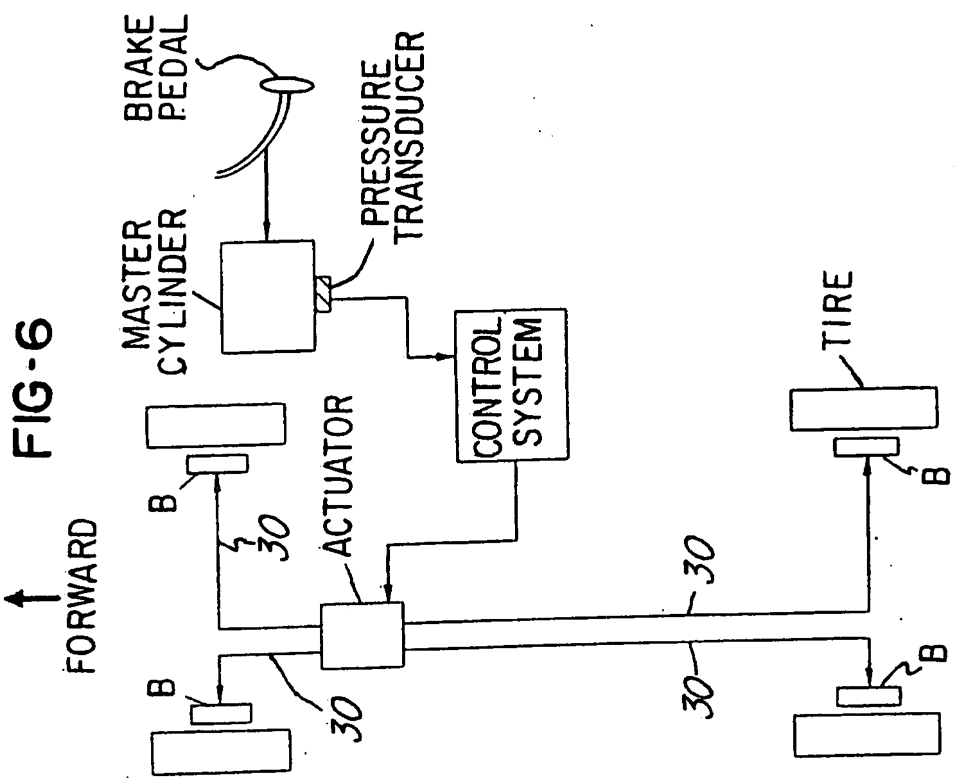
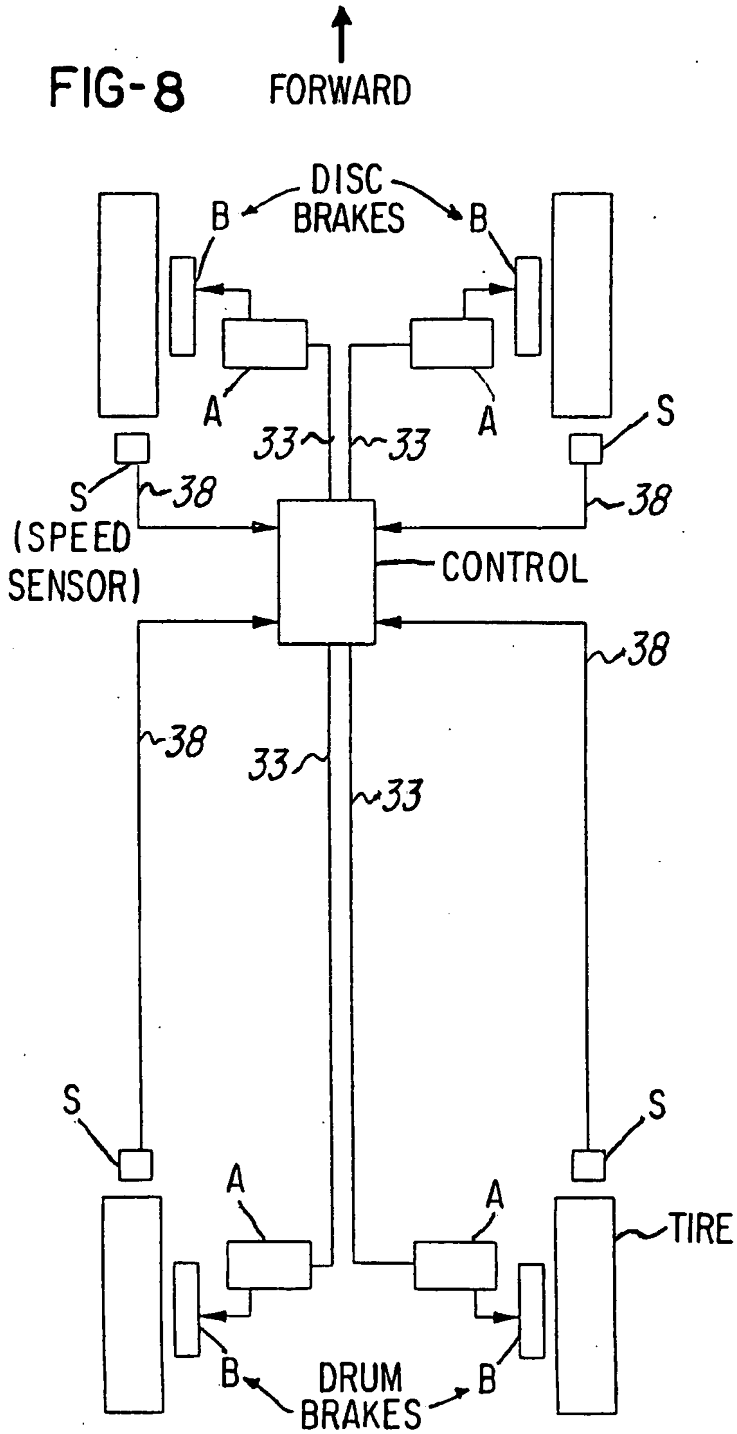

FORWARD
B
30
ACTUATOR
B
30
MASTER
CYLINDER
BRAKE
PEDAL
PRESSURE
TRANSDUCER
CONTROL
SYSTEM
30
30
TIRE
B
B

FIG-8


FORWARD
DISC BRAKES
B
B
A
A
S
33
33
38
38
S
(SPEED SENSOR)
CONTROL
38
38
33
33
S
S
A
A
TIRE
B
B
DRUM BRAKES

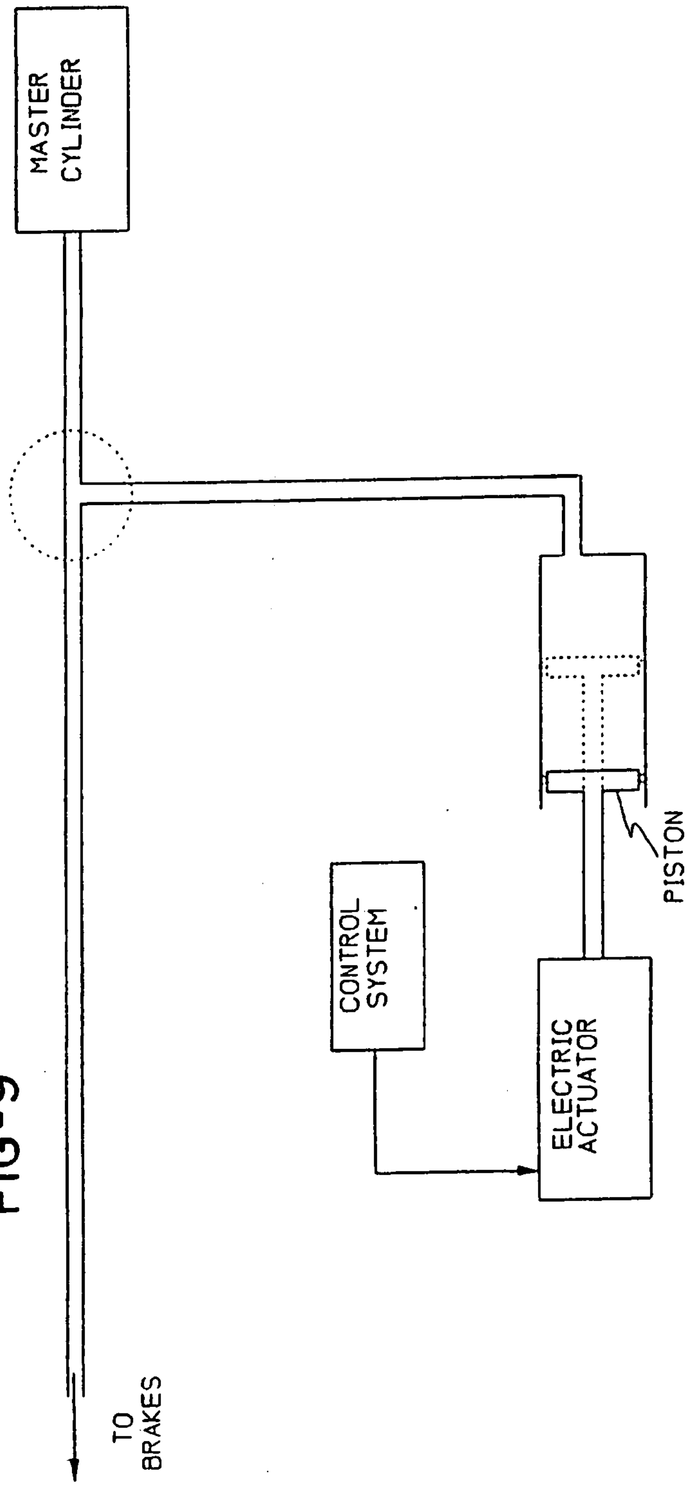

MASTER CYLINDER
PISTON
CONTROL SYSTEM
ELECTRIC ACTUATOR
TO BRAKES

FIG-9

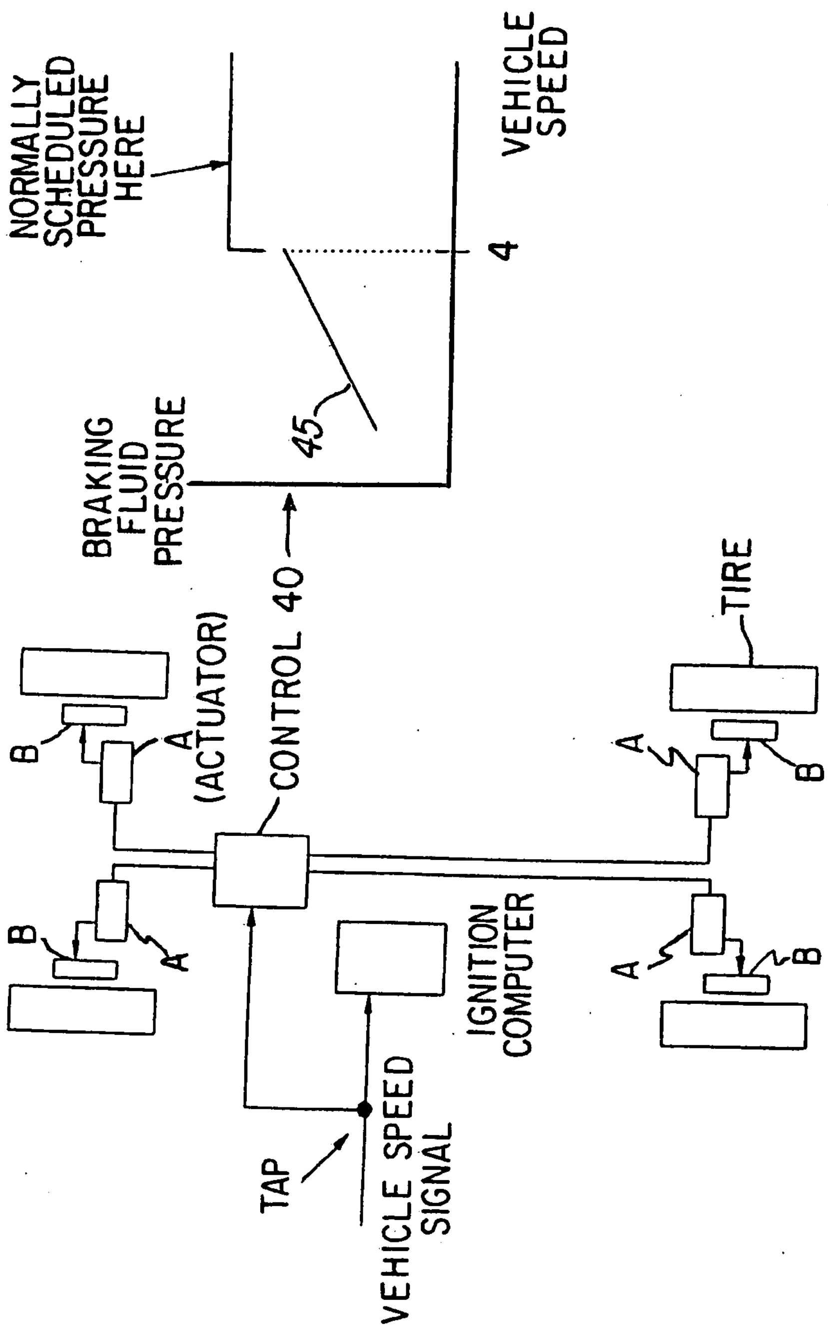

NORMALLY SCHEDULED PRESSURE HERE
VEHICLE SPEED
4
45
BRAKING FLUID PRESSURE
CONTROL 40
A (ACTUATOR)
B
A
B
TIRE
A
B
A
B
IGNITION COMPUTER
TAP
VEHICLE SPEED SIGNAL

FIG-10

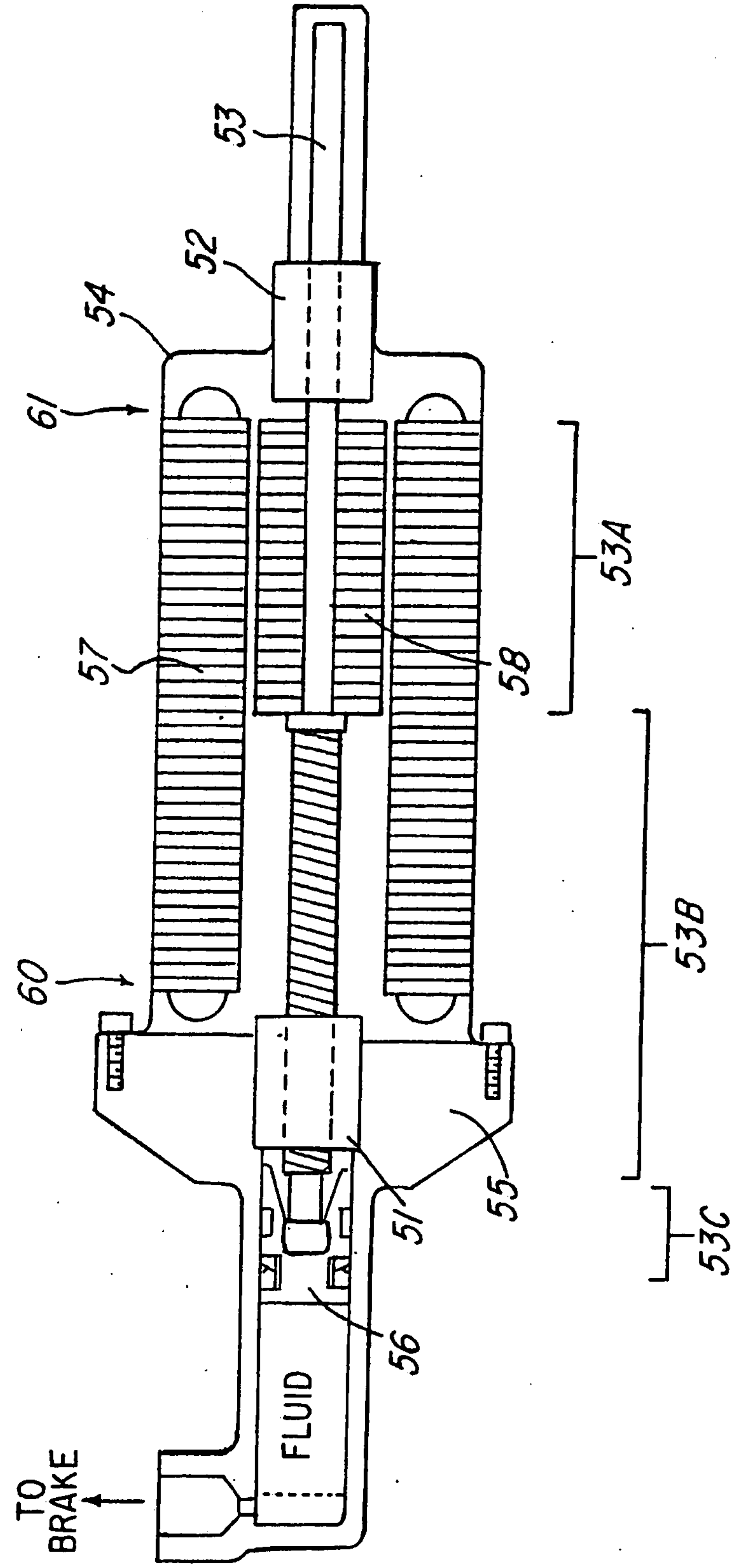


FIG-11

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/07176

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B60T8/32 B60T8/26 B60T13/74

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B60T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE,A,34 24 912 (ALFRED TEVES) 16 January 1986 see claims 1,2,4,5,7,12-14 see page 10, last paragraph see page 15, paragraph 3; figure 1 see page 17, last paragraph; figure 2	1-5, 11-15
A		6,7,9,10

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 July 1996	24.07.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Meijs, P

Form PCT/ISA/210 (second sheet) (July 1992)

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INTERNATIONAL SEARCH REPORT

In .tional Application No
PCT/US 96/07176

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,5 348 123 (TAKAHASHI ET AL.) 20 September 1994 see column 2, line 34 - line 46 see column 8, line 32 - line 34 see column 5, line 1 - line 17 see column 5, line 27 - line 30; figures 3,4 see column 7, line 30 - column 8, line 11; figure 6	1-6
A		7,10,11, 14

X	GB,A,2 283 067 (MERCEDES-BENZ) 26 April 1995 see page 13, line 7 - line 28 see page 19, line 1 - page 22, line 6; figure 1 see page 26, line 12 - page 27, line 15; figure 2	1-5, 11-15
Y		8,9
A		6,7

X	DE,A,22 08 936 (TELDIX) 6 September 1973 see page 8, last paragraph - page 9, paragraph 2; claims 1,2,4-6,8,9,15,17,20; figures 1,2A,2B	1,2,4,5, 7
Y		8,9
A		6,10,11, 14,15

X	US,A,4 760 529 (TAKATA ET AL.) 26 July 1988 see column 1, line 9 - line 68 see column 8, line 49 - column 9, line 2; figure 10	1,2,4,5, 10
A		2,6,7, 11-14

X	US,A,4 327 414 (KLEIN) 27 April 1982 see abstract; figures 1,7 see column 3, line 29 - line 44 see column 7, line 41 - line 44	1,2,4,5, 10
A		2,6,7, 11-14

X	DE,A,33 42 552 (VOLKSWAGEN) 5 June 1985 see page 6, paragraph 2 - page 7, paragraph 1; figure	1,3,14, 15
A	see page 5, paragraph 3	7,8,11

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3

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,4 850 650 (ECKERT ET AL.) 25 July 1989 see the whole document	1,2,4,5, 11
A		6-9,14, 15
X	DE,A,35 18 715 (DAIMLER-BENZ) 27 November 1986 see claims 1,5; figure	1,6
X	EP,A,0 292 648 (ALFRED TEVES) 30 November 1988 see column 13, line 6 - column 14, line 42; figure 4	1
A		2,6,8-11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 96/07176

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
DE-A-3424912	16-01-86	NONE		
US-A-5348123	20-09-94	JP-A-	5060157	09-03-93
		DE-A-	4229042	04-03-93
GB-A-2283067	26-04-95	DE-C-	4335769	08-12-94
		FR-A-	2711342	28-04-95
		JP-A-	7186921	25-07-95
DE-A-2208936	06-09-73	NONE		
US-A-4760529	26-07-88	JP-B-	7107653	15-11-95
		JP-A-	60068409	19-04-85
		DE-A-	3434793	11-04-85
		GB-A,B	2147434	09-05-85
US-A-4327414	27-04-82	DE-A-	2926017	12-02-81
		FR-A,B	2460238	23-01-81
		GB-A,B	2053394	04-02-81
		JP-C-	1495368	16-05-89
		JP-A-	56039949	15-04-81
		JP-B-	63045336	08-09-88
DE-A-3342552	05-06-85	NONE		
US-A-4850650	25-07-89	NONE		
DE-A-3518715	27-11-86	NONE		
EP-A-292648	30-11-88	DE-A-	3717236	08-12-88
		DE-A-	3717237	08-12-88
		DE-A-	3717238	08-12-88
		DE-A-	3873822	24-09-92
		JP-A-	63306958	14-12-88
		US-A-	4838622	13-06-89